MODE OF RESIDUAL ACTION OF PARATHION AND ENDRIN ON THE NEWLY HATCHED LARVAE OF THE PADDY BORER, *TRYPORYZA INCERTULAS*, WITH A SPECIAL REFERENCE TO SOME PROBLEMS RESPONSIBLE FOR INCONSISTENT CONTROL OF THE LARVAE BY FOLIAR SPRAYS[1]

By

S. Y. LEE and W. Y. HONG

Although parathion and endrin have long been used for the paddy borer control in Taiwan, little information has been published concerning how residues of these chemicals effectively act upon the newly hatched larvae. In order to clarify this problem the authors conducted the following studies.

In the first place, mode of gaining entrance in the paddy plants by the newly hatched larvae was investigated. Such observations were previously made briefly by Shiraki (1917). Liang (1956) also reported that on seedlings, 68 per cent of the newly hatched larvae made entrance holes on the outside of the leaf sheaths and 32 per cent entered the plants through the openings in the top of the leaf sheaths on the plants 30 days after transplanting, 34 per cent made entrance holes and 66 per cent crawled inside through the leaf sheath openings; on the plants 60 days after transplanting, 25 per cent bored entrance holes, and 75 per cent found their way into the plants through the leaf sheath openings. The results of the present test conducted by the authors agree in general with those shown by Liang. Table 1 summarizes the data, which show that on young plants very roughly about 50 per cent of the larvae bore entrance holes to get inside. Time required for completing boring a hole varied from about 5 to 20 minutes, depending on age of the plants. On older plants, however, the majority of the larvae did not make entrance holes, but tried to find some openings on the plants through which they could readily reach a sheltered area to bore into the tissue for feeding. Such openings are usually found at the top of the leaf sheaths (Plate I, Fig. 2). After getting behind the leaf sheaths, some larvae (15 to 53 per cent) were found to bore first into the outer leaf sheaths for feeding, but usually all of them reach the center of the straw in a day or so, then feed downward to the base, causing the central leaves to wither.

It is clear from the foregoings that mechanisms by which the residues of endrin or parathion applied as a foliar spray may act on the invading newly hatched larvae are: 1) contact poisoning or fumigation with the toxicant present on the surfaces of the plants, 2) stomach poisoning due to ingestion of the plant tissue in

(1) This work was supported by grants from the National Council on Science Development and the Joint Commission on Rural Reconstruction.

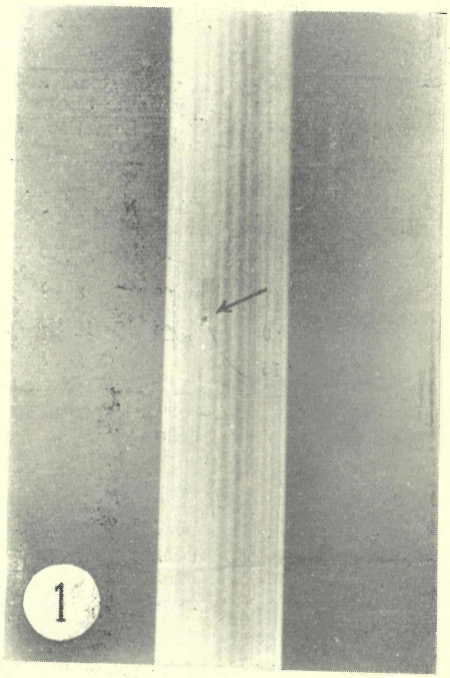
Table 1. Mode of reaching inside the paddy plants in different stages of development by the newly hatched paddy borer larvae, *Tryporyza incertulas*

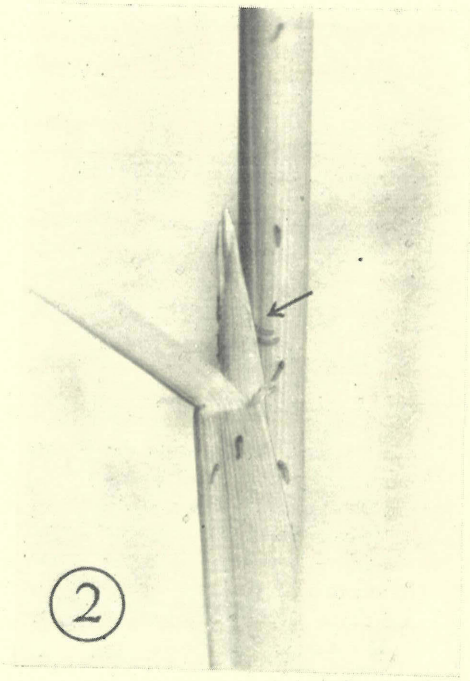
Date Examined	Age of Plants After Trans-planting (Days)	No. Of Insects Tested	Per Cent Of Larvae Reached Inside The Plants By Route Shown	
			Entrance Hole	Leaf Sheath Openings
Oct. 24 1961	35	64	56	44
May 17 1962	57	40	43	57(e)
Sept. 22 1961	65(a)	36	21	79(f)
	65(b)	37	11	89(g)
	65(c)	20	0	100(h)
	65(d)	37	16	84(i)

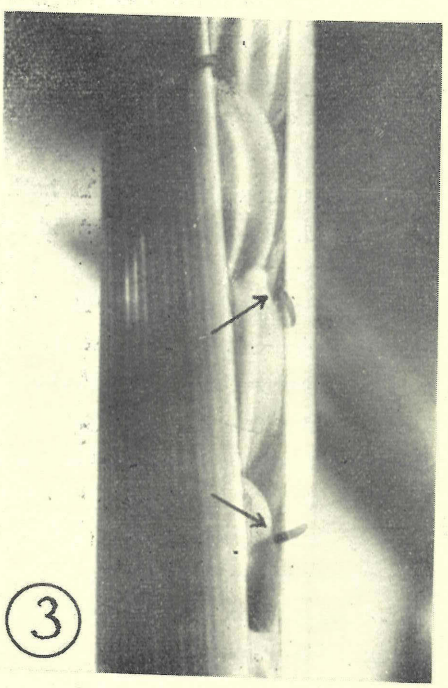
(*a*) Ears were not yet formed within the straws.
(*b*) Ears were formed inside the straws.
(*c*) Ears partly emerged in the air.
(*d*) Ears completely emerged in the air.
(*e*) Of these larvae, 53 per cent first fed in the outer leaf sheaths, and 47 per cent in the inner leaf sheaths. In either case, they reached the center of the straw in a day or two and a withering central leaf was produced.
(*f*) Of these, 20 per cent first ate the outer leaf sheaths and 80 per cent fed in the inner leaf sheaths.
(*g*) Of these larvae, 15 per cent first fed in the outer leaf sheaths and 85 per cent in the inner leaf sheaths.
(*h*) All quickly entered the plants through the opening in the top of the flag leaf sheaths that surrounded the partly emerged panicles (Plate I, Fig. 3), and most of them bored into the glumes, feeding on the stamen etc.
(*i*) The larvae crawled into the plants under the margin of the flag leaf sheath that enveloped the axis of the panicle (Plate I, Fig. 4). Most of them appeared to feed on the panicle after getting inside.

which the toxicant penetrates or translocated, or 3) combined action of the both.

To settle this question, four tests were conducted. Paddy plants used were planted in pots, 56-day-old after transplanting. Their outer leaf sheaths that were coming off the straw were removed before the treatment, so as to prevent the test larvae from quickly crawling inside. The chemicals were emulsifiable concentrates, applied at a 0.05 per cent concentration with a hand sprayer, care being taken that through coverage could be obtained. In test one, spraying was made on May 16, 1962. The test larvae were released 40 hours later, and kept crawling on the plants for about 30 to 50 minutes, then removed to untreated fresh plants for feeding. The mortality of the larvae was investigated 3 days after treatment. In test two, sprays were applied on June 1, 1962. The larvae were released 23 hours later, and kept crawling on the plants for about 30 to 50 minutes, then transferred to fresh untreated plants for feeding. The larvae were examined 3 days later, the data of these tests are summariszed in Table 2, which show that the surface residue of endrin did not kill the larvae by contact with the legs or by fumigation when released 40 or 23 hours after spraying, but the surface residue of parathion appeared to have a slight toxic effect upon the larvae. However, whether this was due to fumigation or contact poisoning was not clear. These data show that practically







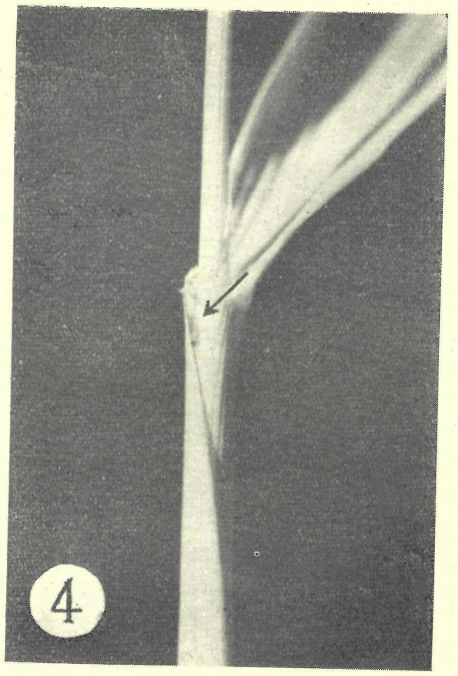


PLATE I

Tillers of paddy at different stages of development, showing various entrances of the newly hatched larvae of the paddy borer: Fig. 1. Entrance hole bored on a young straw; Fig. 2. Opening on the top of the leaf sheath; Fig. 3. Open flag leaf sheath at heading stage; Fig. 4. Loose top of the flag leaf sheath of completely headed plant.

Table 2. Toxicity of surface residues of endrin and parathion against the newly hatched paddy borer larvae kept crawling for 30 to 50 minutes on the plants 40 or 23 hours after spraying. May-June, 1962

Treatment (0.05%)	Per Cent Mortality Of The Larvae, And (No. Of Larvae Tested)	
	Test one(a)	Test two(b)
Untreated	0 (34)	0 (7)
Endrin	0 (43)	0 (7)
Parathion	9.6 (52)	11 (9)

(*a*) Larvae released 40 hours after spraying.
(*b*) Larvae released 23 hours after spraying.

residual kill of the newly hatched larvae was not due to the surface residues of these chemicals.

Test three and four were conducted to study fate of the larvae that crawled mostly through the top of the leaf sheath into the treated plant. The plants used were the same as those used in the above tests. In test three, sprays were applied on May 16, 1962. The larvae were released 40 hours after spraying, and were examined 3 days later. From 5 tillers treated with parathion, 46 larvae were recovered; all were killed, 91 per cent of them was found in the tissue of the leaf sheaths and 9 per cent between the outermost and the second leaf sheaths. In 4 tillers sprayed with endrin, 45 larvae were recovered, of which 82 per cent was killed in the tissue of the leaf sheaths, 9 per cent between the outermost and the second leaf sheaths, and 9 per cent feeding normally in the tissue of the leaf sheaths (mortality 91 per cent). From 3 untreated tillers 36 larvae were recovered; all feeding normally in the tissue of the leaf sheaths. The results of this test and the data of Table 2 suggest that residual effect of parathion and endrin might be due primarily to stomach poisoning of the larvae by the feeding in the leaf sheaths into which the toxicants were translocated. Another test was replicated using similar methods and materials as above, except that no adjustment was made on the plants, that is, the loose outer leaf sheaths were left as they were. Sprays were applied on June 1, when the plants were 72-day-old, and the larvae were released 42 hours after spraying. The results were examined 13 days later, and are shown in Table 3.

It is not quite clear from the data of Table 3 whether or not the larvae were killed mainly by stomach poisoning. However, it is clear from these data and data of Table 2 that residual effect of endrin and parathion is due to the penetration residues, not to the surface residues.

Here, considerations should be made on several problems that make presence of sufficient amount of penetration residue in the paddy plants difficult when applied as foliar sprays. Firstly, deposits of the toxicant on the lower part of the tiller where the insects attack is prevented by dense growths of the leaves beyond one or two month-period after transplanting, when sprays are applied from their top. When

Table 3. Residual toxicity of endrin and parathion on the newly hatched paddy borer larvae crawled into the plants through the opening at the top of the leaf sheaths. June, 1962

Treatment (0.05%)	Per Cent Mortality Of Larvae And (Total No. Recovered)	Per Cent Mortality Of Larvae Recovered From Leaf Sheaths Shown		Per Cent Distribution Of The Dead Larvae Recovered At Varying Distances From The Entrance (Mm. Downward The Straw)		
		Outermost	Inner	1-5	5-10	Below 10
Untreated	0 (25)(a)	—	—	—	—	—
Parathion	100 (36)(b)	78	22	80	13	7
Endrin	56 (16)(c)	67	33	33	56	11

(*a*) Most of the larvae were feeding in the center of the straw.
(*b*) Six larvae went 1 mm. upward the straw and were killed.
(*c*) None went upward the straw. The 7 living larvae were all in the center of the straw.

the nozzle is inserted between the rows of the plants and sprayed sideways, better deposits on the straws can be obtained, however it is still difficult to cover the tillers in the center of a hill. Even if good coverage were possible, it would yet be difficult to have uniform or regular translocation of the toxicant into the inner part of a tiller since the tiller is not one-bodied in the aerial part, but consists of a group of separate leaves that are connected only at the base, which in younger plants is under the soil, or at the nodes on older plants whose stems appear above the ground. In fact, the data of a test to investigate residual effect of endrin and parathion applied as foliar sprays under field conditions in two ways on 2-month-old plants of the first crop show that little residual effect is obtained with these compounds when applied from the top of the plants at the standard rate of 1,200 liters per hectare. When applied sideways, parathion showed much better results, but endrin was still poor at the standard rate of application, and gave only some effect at a double dosage. The data of this test are shown in Table 4.

Table 4. Comparative residual effect of endrin and parathion against the newly hatched paddy borer when applied from the top and the side of the plant (test insect released 3 or 4 days after spraying). May, 1962

Treatment (0.05%)	Dosage l./hec.	Direction Of Spraying	No. Of Tillers Whose Tips Withered/Total Examined (Four Replicates)			
Untreated			19/43	24/47	13/48	19/47
Endrin	1,200	Top	26/51	13/44	14/48	11/52
Endrin	1,200	Side	12/59	12/51	10/52	11/50
Endrin	2,400	Side	3/38	8/49	8/50	5/46
Parathion	1,200	Top	18/43	13/53	16/45	15/49
Parathion	1,200	Side	0/54	3/52	0/63	0/47

Although no test was made on initial effect, it is clear from these data that consistent control of the larvae is difficult with foliar sprays at the normal rate of 1,200 liters per hectare applied from the top of the plants with a knapsack sprayer.

Residual control with various foliar sprays becomes particularly poor on the plants whose ears are still partly enclosed by the flag leaf sheath. (Lee and Hong 1963) As already mentioned, on such plants the larvae very quickly crawl into the plant through the open flag leaf sheath and feed in the glumes or in the axis of the ear in which little or nonlethal amount of the toxicant may be translocated by a foliar application. Therefore, to secure better control of the larvae, studies on other methods of treatment or efficiency of other spraying equipments must be conducted.

It is interesting to note here, however, that in spite of this fact, in some field tests (Liang and Liu 1958; Tao 1958 a, b; 1963) significant increase in yield or reduction of white ears over the control plots has been obtained with endrin or parathion treatment. In these tests no investigation was made on how the borers were destroyed by the treatments, and the effect was determined only by increase in yields or, in addition, by reduction of white or dead ears, which could be also caused by some other insects. As is found in some of the tests conducted by Tao et al. (1963 a, b) increase in yields was not always in accordance with reduction of the white ears. This suggests that the effect might have been due to control of some other insects or diseases. It was neither clear in these tests whether decrease of white ears, presuming they were all caused by the paddy borer, was due to destruction of the larvae, or moths or eggs. Such considerations become important since pot screening of insecticides in Taiwan has usually been conducted against the larvae feeding within the plants and those hatching after treatment. Certainly the larvae can thus be killed when every tiller in a hill is throughly covered with the spray. However, as already pointed out kill of the larvae in the plants two months after transplanting or at the heading stage (Lee and Hong 1963) can not be expected by foliar sprays when applied from the top of the plants at the normal rate.

It is therefore questionable that in many field tests where significant results were obtained, the effect of endrin, parathion or some other treatments was due to kill of the larvae feeding within the plants or hatching later on. These treatments might have been acting on the eggs; or on the moths that were either destroyed or merely repelled. Although such repellent action of endrin or parathion is questionable, it should be considered that if their effect were due to repellent action, the moths would then concentrate on the control plots and thus make the results of the control look abnormally phenomenal. It is obvious therefore that when the mode of action of certain treatment is not clear its evaluation should not be made just on basis of relative results obtained in the treated plots and in the control, but it should be finally studied in the field where no control plot is used.

Kill of the invading larvae by direct hit with foliar sprays does not seem great as time period during which the newly hatched larvae or the migrating larvae remain outside the plants is but a fraction of their life.

At any rate, it is clear from these results that detailed field studies should be conducted to investigate what stages of the insect are being mainly controlled by

foliar sprays under certain conditions of the plants, so that more correct laboratory screening of insecticides can be made by using appropriate stages of the borer as test insects.

SUMMARY

Studies were made to investigate how residues of parathion and endrin acted on the invading newly hatched larvae of the paddy borer, *Tryporyza incertulas* under laboratory conditions. The results obtained show that practically residual kill of the larvae is not due to the surfaces residues, but to the penetration residues of these chemicals.

Discussions were made on the difficulties to secure sufficient amount of penetration residues in paddy plants by a foliar application of sprays, and also on possible mode of action of these chemicals upon the insect under field conditions.

LITERATURES CITED

(1) Lee, Sung-yang and W. Y. Hong (1963): Residual toxicity of some insecticides against the newly hatched larvae of the paddy borer, *Schoenobius incertulas*. Agri. Res. 12(3):40-51.

(2) Liang, T. T. (1956): Effect of certain ecological factors upon the chemical control of the paddy borer. Ann. Rep. Taiwan Agri. Res. Ins. 1956. pp. 51-53.

(3) Liang, T. T. and H. H. Liu (1958): Tests on some insecticides against the paddy borer (*Schoenobius incertulas* WALKER) larvae. Taiwan Agri. Res. Inst. Bul. No. 18.

(4) Shiraki, T. (1917): Paddy borer, *Schoenobius incertellus* Wlk. Agri. Exp. Sta. Gov. Formosa. Special report No. 15.

(5) Tao, Chia-hwa (1958), a: Control of paddy borer on the second rice crop in 1957. Jour. Econ. Ent. 51(3):411.

(6) Tao, Chia-hwa (1958), b: Field tests of insecticides against paddy borer in Taiwan from 1953-56. Jour. Econ. Ent. 51(5):571-73.

(7) Tao, Chia-hwa (1963): Control of *Schoenobius incertulas* Walker and *Chilo suppressalis* Walker and *Seamia inferens* Walker on the second rice crop in central and south Taiwan in 1962. Agri. Res. 12(3):52-58.

(8) Tao, Chia-hwa, C. C. Tang and J. M. Yu (1963), a: Control of paddy borer *Schoenobius incertulas* Walker on the second rice crop in Taiwan from 1958-1961. Plant Prot. Bul. 5(3):279-84.

(9) Tao, Chia-hwa, C. C. Tang and J. M. Yu (1963), b: Field tests of pesticides against paddy borer and sheath blight on the second rice crop in Taiwan from 1959-1960. Plant Prot. Bul. 5(3):285-88.

Parathion 及 Endrin 對一點螟蛾初孵幼蟲之殘留作用程序，特別關於莖葉噴射液劑對幼蟲防治無常效之若干問題之討論

李 淳 陽　洪 文 堯

摘　要

本研究旨在觀察室內條件下 parathion 及 endrin 之殘毒對爲害之一點螟蛾初孵幼蟲如何作用。於所獲結果中示出對該幼蟲之實際殘效並非由於表面殘毒，乃在於該等藥劑之滲透殘毒。

以莖葉施藥法使用之噴射液劑使稻株中獲得足量滲透殘毒之困難及該等藥劑對田間條件下之該蟲之可能作用程序於本文中均曾作討論。